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ABSTRACT

This study investigated whether age, sex, speed, and practice affects the acquisition of coincidence-anticipation (C/A) performance accuracy of children ages seven to twelve. (C/A refers to the ability to make a motor response coincident with the arrival of an object at a designated point.) The subjects used in this study were 84 elementary students. Fourteen subjects, seven boys and seven girls, were included in each of six age groups. The apparatus employed consisted of a wooden track the length of which traveled a gravity propelled car, and a subject's anticipation switch. The testing procedure began with subjects depressing the switch at the experimenter's command. The car was then released and travelled down the track. When the car passed a first switch, two timers were activated. As the second switch was passed, one time clock was stopped. The other timer stopped at the moment the subject judged that the car and switch were in coincidence. A subject's score was the absolute difference between the times recorded on the two clocks. Results revealed that while 11 and 12 year olds' performances did not differ significantly, both exhibited more accurate performances than the 10, nine, and eight year olds. The performance accuracy of the seven year olds was significantly less than that of each of the other five age groups. Males' performance was superior to females, but was attributed to the testing situation as opposed to a biological difference. Practice was shown to influence accuracy positively. (DMT)

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The Effect of Age, Sex, Speed and Practice on C/A Performance of Children

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Introduction

(1) The successful execution of many motor skills requires individuals to make appropriate responses to objects in motion. One of these is the ability to intercept a moving object. The ability to make a motor response coincident with the arrival of an object at a designated point has been termed coincidence-anticipation (C/A) (1).

(2) Examples of typical motor skills employing this facet of performance are bountiful and include such activities as hitting a pitched baseball, trapping a soccer ball, returning a tennis volley, hitting a shuttlecock, dribbling a basketball, shooting skeet and numerous others.

(3) While the importance of the role of C/A in motor performance is well accepted, a review of the literature reveals a paucity of investigations of this component of skill. There are likewise very few studies that address themselves to the acquisition of C/A proficiency. Schmidt (15) has reported a review of both areas.

(4) Considering the important role of motor skills in the activities and lives of children one might naturally expect a number of studies in this area. Unfortunately, very few have been reported. Only investigations by Bruce (5), Williams (18), Kay (12) and Stadulis (17) appear to be the exception.

(5) The study by Stadulis investigated the effect of age, sex, speed-rate and practice on the C/A performance of children 7, 9 and 11 years old. One of his

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results indicated that C/A accuracy improved with age but only at the slowest of four speeds. Analysis of the data indicated that younger subjects were actually more proficient in performing fast C/A responses than older subjects. Stadulis has stated that this finding "might indicate a different teaching technique (should) be employed." (17) That is, the traditional technique of having children practice C/A skills by employing slower moving objects needs careful review, possible revision and/or rejection. Consequently, if these results can be substantiated through replicated studies, careful consideration to Stadulis' suggestion would seem warranted.

(6) Accordingly, it was the purpose of this study to investigate whether age, sex, speed, and practice affect the acquisition of C/A performance accuracy of children ages 7 through 12.

Method

(7) Subjects. The subjects used in this study were 84 students enrolled at Holy Family Catholic Elementary School in Richmond, Indiana. Fourteen subjects, seven boys and seven girls, were included in each of six age groups: 7, 8, 9, 10, 11 and 12 years. Age was determined by years with months disregarded. The subjects were from a cross-section of socio-economic backgrounds. All subjects volunteered to participate in the study.

Apparatus

(8) Apparatus. The apparatus employed in this study consists of three parts: 1) a wooden track the length of which travels 2) a gravity-propelled car and 3) a subject's anticipation switch.

(9) The track was 15 feet, 4 inches by 6 inches by 6 inches and consisted of two sections, the runway and the shute. The runway was 12 feet long and suspended in the horizontal plane three feet above the floor. The shute was 40 inches long and inclined at a 30-degree angle from the runway. A slot 5/8 inches wide ran the length of the track and separated two dado grooves 5/8 inches wide and 1/4 inch deep which served as tracks for the car. Two toggle switches were attached to the base of the track, distal side, and parallel to the track. The lever of each switch was extended 2 inches by a small steel rod set into and glued in a small hole drilled in the conventional lever.

(10) The car was $7\frac{1}{2}$ inches by $2\frac{1}{4}$ inches by 4 inches made of wood with masonite sides and ball bearing roller skate wheels. Extending from the side of the car was a 1 3/4 inch by 3/8 inche bott which "tripped" both of the track toggle switches as the car passed.

(11) Projecting from the bottom of the car was a 12 inch long, 1/8 inch wide steel rod to which a 2 3/4 inch styrofoam ball was attached at the distal end.

(12) The first track switch was attached at the proximital end of the shute. As the car passed the ball extending from the side it tripped the switch activating two .01-second timing clocks. One recorded the actual time; the other recorded the subject's anticipation. The second track switch was positioned at the terminal end of the runway. Its activation point coincided with the proximital edge of a metal flag 3 inches by $5\frac{1}{2}$ inches painted red and hanging by a bicycle spoke below the track. This switch, when tripped by the passing car, deactivated the actual time clodk.

A buffer of sponge rubber was positioned at the terminal end of the track to absorb the impact of the moving car.

(13) The subject's switch was a 6 inch by 1 3/4 inch hasp secured in the reverse position to an 18 inch by 12 inch by 3/4 inch base. A thin rubber pad glued to the bottom of the base prevents slippage. Two 5/8 by 1/8 cooper screw and bolts served as electrical contact points. One set was attached to the hasp and the other to the base. A small spring positioned in the center of the hasp prevented completion of the circuit without pressure being applied to the hasp. With the release of pressure by the subject the circuit was immediately broken. The hasp was easily depressed. When this switch was released, the subject's anticipation clock was stopped.

Procedure

(14) All testing was conducted in a large room which provided seclusion from the regular school distractions and interruptions.

(15) Subjects were picked up at their classrooms and then taken to the testing room. After name and date of birth were obtained, each subject was instructed as to the nature of his/her participation. It was carefully explained what was expected of the subject and practice attempts were conducted. The S was to watch the ball as it moved from down the track and at the moment the ball was tangent to the metal flag was to have his foot off the anticipation switch. When the experimenter and the subject were satisfied that the procedure was understood, testing was begun.

(16) A trial consisted of the car traveling from one end of the track to the other. The experimenter held the car by the steel rod to which the ball was attached at the upper end of the shute. Markings on the bottom of the shute indicated starting points

for various speeds. Increased speeds were achieved by starting at points a farther distance from the shute runway intersection.

(17) Each trial was preceded by the experimenter saying, "Ready ?" and the subject's affirmative response. Subjects were comfortably seated 15 feet away from the apparatus. The switch was placed on the floor and adjusted according to the subject's height. Subjects each had 24 trials, 3 blocks of 8 trials with 2 trials of 4 speeds in each block. The order of speed presentation was randomly determined. The only restriction was that the same speed could not occur more than twice in succession.

(18) The four different speeds employed in the experiment were: slow (2.00 seconds); medium slow (1.25 seconds); medium fast (.90 second); and fast (.75 second). Variations in speeds were achieved by releasing the car from four different points (heights) on the shute. The consistency of this method was established in a separate investigation with reliability ranging from .901 to .972 for the various rates of speed.

(19) The testing procedure began with subjects depressing the switch at the experimenter's command. The car was then released and traveled down the shute and trough. When the car passed the first switch, the two .01 timers (actual time and estimated time) were activated. As the second switch was passed, the actual time clock was stopped. The estimated timer was stopped at the moment the subject judged that the car and flag were in coincidence. S's were instructed to remove their foot entirely off the switch and leave it off until told to depress the switch again. A subject's score was the absolute difference between the times recorded on the actual and estimated clocks given in hundredths of seconds.

(20) The experimenter recorded the actual and subjects' estimated times and then walked to the end of the track to retrieve the car. As the experimenter reached the car the subject was told to depress the switch. As the experimenter returned to the starting point he manually reset the track switches.

Results

(21) The mean absolute error scores and SD for all performance trials according to age, sex, rate and practice are presented as Table 1.

(22) The effects of age, sex, rate and practice upon C/A accuracy were analyzed employing a 6 x 2 x 4 x 3 factorial design with two within subject factors: rate (slow, medium slow, medium fast and fast) and practice (three blocks of eight trials). A summary of the results for absolute error scores is presented as Table 2. The results indicated that the F ratio for age, $F(5,72) = 7.64$ $p < .05$, was significant at the .05 level. Posteriori comparisons were made between the various age groups and the results revealed that while 11 and 12 year olds' performances did not differ significantly from each other, both exhibited significantly more accurate performance accuracy than each of the 10, 9 and 8 year olds. Furthermore the performance accuracy of the 7 year olds was significantly less than that of each of the other five age groups.

(23) The results revealed a significant difference for the effect of sex on C/A performance accuracy, $F(1.72) = 6.25$ $p < .05$, indicating that for this study boys and girls were responding differently, with the boys' performance significantly superior.

(24) Analysis of the data indicated that the effect of practice on accuracy, $F(3,144) = 30.07$ $p < .05$, of C/A performance was significant. Posteriori comparisons between blocks revealed a significant difference between block one and blocks two and three. However, there was no difference between subjects' performances for blocks two and three.

(25) The rate (speed of the ball-car) did not have a significant effect, as were all the interaction combinations non-significant.

Discussion

(26) The significant F observed for age is in agreement with results previously reported by Stadulis (17). However, in the present study there is not a significant interaction between age and rate as was the case in the Stadulis investigation. While Stadulis observed that younger subjects were more proficient in trials requiring faster C/A performance, such evidence is not replicated here. The results would seem to indicate three groupings of performance ability by age: 7 year olds; 8, 9 and 10 year olds; and 11 and 12 year olds. This might indicate group maturity or possibly the insensitivity of the apparatus to differentiate between age group performance. This would seemingly agree with Williams (18) who concluded that ability to judge the flight of a moving object in three-dimensional space was matured at age eleven. Furthermore, Boyer (4) has stated that the eye-hand coordination became "good" at eight years of age. These results also partially agree with Bruce (5) who found that 6th graders were more proficient than 2nd and 4th graders in catching a ball which required the determination of the ball's velocity and direction. This finding would thus seem to lend some support to the general notion that children's

ability to perform motor tasks requiring a C/A facet improves with age (Halsey and Porter (9)) and/or maturation (Jersild (11)).

(27). The significantly superior C/A performance of boys disagrees with results obtained by Bruce (5), Williams (18) and Stadulis (17). Cratty and Martin (7), however, present evidence supporting a sex differentiation on a task requiring subject to touch a swinging ball. Espenschade and Eckert (8) have concluded that little seems to be known about sex differences and their effect upon C/A performance. Based on observation of S's during the present study, it is hypothesized that the observed difference is the result of the testing situation as opposed to a real biological difference. The boys seemingly were much more interested and attentive, thus resulting in a greater accuracy.

(28) The finding that a significant practice difference occurred between blocks one and two, but not between two and three agrees with similar results obtained by Stadulis and Schmidt (16). In contrast, however, Bahrich, Noble and Fitts (2), Jeeves (10) and Poulton (13, 14) have reported improvement in later stages with testing. These differences in reported results might well be the function of experimental task apparatus.

(29) It is hypothesized for the present study that the observed improvement between only the first two blocks of trials was the result of subjects' becoming familiar with the task rather than actual skill improvement.

(30) Considering the significant role of C/A in many motor skills, it would seem imperative that future investigation consider the effect of extended practice on performance accuracy, the identification of optimal learning periods and the general extension to more complex models and tasks.

TABLE 1

MEAN ERROR SCORES AND STANDARD DEVIATIONS FOR COINCIDENCE-ANTICIPATION PERFORMANCE OF ELEMENTARY SCHOOL CHILDREN

VARIABLE	MEAN ABSOLUTE ERROR	STANDARD DEVIATION
Age		
7	49.38	32.80
8	29.72	17.91
9	29.67	22.49
10	33.50	36.29
11	16.41	15.06
12	18.60	23.86
Sex		
Boys	25.17	25.61
Girls	33.93	29.56
Rate		
Slow	30.78	29.71
Medium Slow	29.09	30.53
Medium Fast	28.93	25.96
Fast	29.40	25.52
Practice		
Block I	38.34	34.41
Block II	25.96	25.59
Block III	24.35	23.12

TABLE 2

SUMMARY OF ANALYSIS OF VARIANCE
FOR COINCIDENCE-ANTICIPATION PERFORMANCE
OF ELEMENTARY SCHOOL CHILDREN

SOURCE	df	MS	F
Between Ss			
Age (A)	5	23576.92	7.64*
Sex (S)	1	19293.75	6.25*
AxS	5	5239.32	1.70
Between error	72	3087.09	
With Ss			
Rate (R)	3	178.61	.52
AxR	15	352.22	1.03
SxR	3	669.13	1.96
AxSxR	15	173.39	.51
RxS error	216	342.17	
Practice (P)	3	19659.75	30.07*
AxP	10	751.68	1.15
SxP	2	482.30	.74
AxSxP	10	342.72	.52
PxS error	144	653.89	
RxP	6	182.11	.52
AxRxP	30	216.41	.61
AxSxRxP	30	407.63	1.16
RxPxS error	432	350.22	

*Significant at the .05 level.

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